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Selective epitaxial growth of $DyBa_2Cu_3O_7$ using $Dy_{1-\delta}Cu_{\delta}O_x$ templates has produced superconducting wires as small as 2 μm in width. A systematic study of the effects of template composition on the superconducting wires was undertaken. The lateral diffusion of Dy and Cu from the template into the wires was measured with characteristic x-ray maps. Optimized templates were found to be useful in defining device-size features without degradation of the superconducting properties of the films.

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AASERT: HIGH TEMPERATURE SUPERCONDUCTING COMPOUNDS

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Introduction

Superconducting junctions, especially Josephson tunneling junctions, are the key to small scale applications of superconductivity in the areas of sensing and electronics. Although tunneling junctions of several types have been realized, and are even commercially available, there is no junction fabrication technology which is completely controlled and reliable, and achieves levels of performance comparable to those easily achieved with low temperature superconductors requiring hydrogen or helium-based refrigeration.

Previously we reported work in two directions focused on fabricating high quality tunneling junctions, the use of the block-by-block growth technique to engineer planar tunneling junctions, and the use of scanning tunneling microscopy (STM) to produce junctions by direct writing. Mr. P. Kraus has been the graduate student supported by this grant.

Our approach to producing junctions differed from other writing schemes in that instead of ablating material or producing local damage to generate a barrier, we produced an oxygen deficiency track by writing across an ultrathin film with an STM in the tunneling mode. Some very encouraging results were achieved. We observed surface modification effects in our films bought about by the STM. The surfaces appear to be both imaged and *modified* by the STM. Some STM-damaged regions showed a transient response to light which did not appear to be bolometric in nature. However, the bottom line was that all effects were unstable with time. For this reason, we terminated this direction of research, and have been focusing on planar junctions, involving vertical transport, as described above.

To achieve the goal of making vertical transport measurements in oxide epitaxial heterostructures, a selective epitaxy scheme has been developed. The purpose of this effort was to realize clean interfaces between the materials of interest while minimizing the amount of post-growth processing needed.

Selective Epitaxy of DBCO using an Amorphous DCO Substrate

Selective epitaxial growth of $DyBa_2Cu_3O_7$ using $Dy_{1-D}Cu_{\delta}O_x$ templates has produced superconducting wires as small as 2 μm in width. A systematic study of the effects of template composition on the superconducting wires was undertaken. The lateral diffusion of Dy and Cu from the template into the wires was measured with characteristic x-ray maps. Optimized templates were found to be useful in defining device-size features without degradation of the superconducting properties of the films.

This approach was found to be very effective in defining small superconducting features. Of the two constituents in the template, Cu appears to be an active element, possibly altering the DBCO by driving it out of stoichiometery. Minimizing the total amount of Cu in the template while still thoroughly damaging the DVCO on top of the template is possible by doping a layer of copper oxide near the surface of the template. This technique has resulted in nearly identical superconducting properties in wires ranging in width from 5 μm to 100μm. The doping of a dysprosium oxide template with another active element such as Si or Ti could lead to improved results by using the dysprosium oxide to restrict the diffusion of the active element and allow for smaller features.

Although we have not reached sub-micron length scales, the use of templates of this type offers opportunities for *in situ* patterning. Because the template is formed from the constituents of DVCO, it is possible to use physical masks and place templates on freshly deposited films *in situ*. Windows can be defined and subsequent layers in a heterostructure patterned, by selective epitaxy, as they grow. The feature size of physical masks is typically much larger than the micron-scale features which we have demonstrated. Thus a minimum of damaging post-growth processing would be needed to form clean device configurations.

Personnel Supported

.Mr. P. A. Kraus

Publications

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2. "Differential conductance of the ferromagnet/superconductor interface of $DyBa_2Cu_3O_7/La_{2/3}Ba_{1/3}MnO_3$ heterostructures," V. A. Vas'ko, K. R. Nikolaev, V. A. Larkin, P. A. Kraus, and A. M. Goldman, Appl. Phys. Lett. **73**, 844 (1998).
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